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COMMERCIAL CREW



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Commercial Crew Program Status to the NASA Advisory Council





Agenda



- **Agenda**
 - **Commercial Crew Status**
 - Program Progress
 - Timeline to the International Space Station
 - **Boeing PAT/OFT/CFT Mission Status**
 - **SpaceX IFAT/Demo-2 Mission Status**
 - **Enabling Commercial Spaceflight**
 - **Space Act Agreement Status**
 - Blue Origin
 - Sierra Nevada Corporation
 - **Summary**



Program Progress

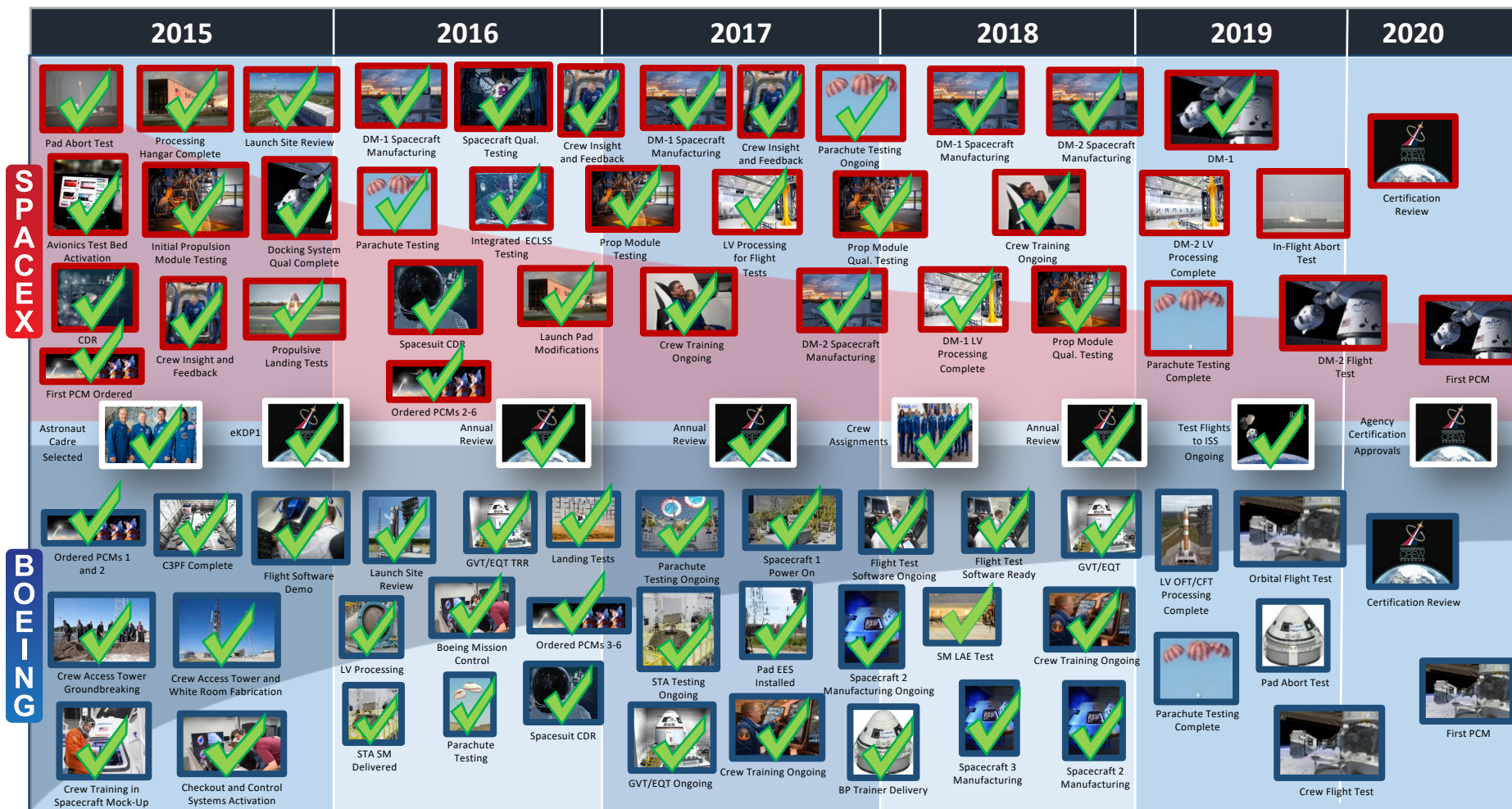


Commercial Crew has made significant progress over the last quarter, notably:

- **Mission planning and preparations for CCP missions continue:**
 - Official Launch Dates
 - December 17, 2019: Boeing Orbital Flight Test (uncrewed demo)
 - Under Review: SpaceX Demo Mission 2 (crewed demo)
 - Under Review: Boeing Crewed Flight Test (crewed demo)
- **Space hardware manufacturing, testing and qualification continue**
- **Both providers are making tangible progress toward flights to the International Space Station**
- **Continued engagement from CCP as the providers perform critical test and verification events**
- **CCP continues the burn down of key certification products for both Boeing and SpaceX**
 - Progress for each is included in provider-specific sections of this briefing



Timeline to the International Space Station





Boeing PAT/OFT/CFT Mission Status





Boeing Pad Abort Test Status

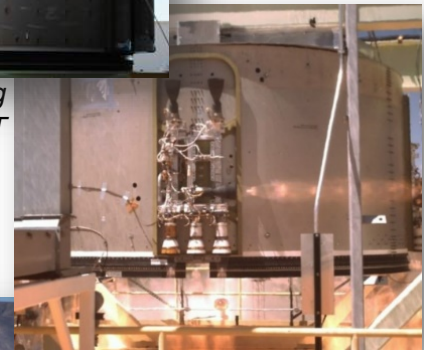


Pad Abort Test (PAT) Trending to Early November Launch Readiness - Target Date 11/4/19

- **Purpose is to validate end-to-end performance and functionality of the Launch Abort System**
- **Test Summary**
 - Mode Ia Abort from pad abort conditions
 - Test Location: White Sands Missile Range (WSMR)
 - Vehicle Configuration:
 - Spacecraft-1 CM and SM
 - ULA-delivered flight-like LVA including updated abort vent doors
 - CCP to support from WSMR and from MCC-H
- **Status**
 - PAT predicted performance delivered 7/31/19, showing margin against Commercial Crew Pad Abort requirement
 - NASA GNC IV&V shows good agreement with Boeing results
 - LVA abort vent door test successfully completed 8/15/19
 - CM/SM Mate Complete 9/18/19
 - SC1 CCV Power-up Complete 9/21/19
 - Set-Up for MMH Prop Loading 10/19/19
 - Test Readiness Review 10/28/19



Spacecraft being readied for PAT



Testing on Starliner's in-space maneuvering and launch abort systems





Boeing Orbital Flight Test Status



Orbital Flight Test (OFT) Trending to Mid-December Launch Readiness - Target Date 12/17/19

- **Spacecraft #3**

- CM/SM mate complete 10/17/19
- CM Integrated Avionics Acceptance testing complete
 - Boeing Integrated Propulsion Control R&R and regression testing complete
 - Prop regulator rebuild and retest complete
 - Final CM build and RF testing completed prior to CM/SM mate
- Preparations for final CCV acceptance testing in work
- Final close-outs in work

- **Atlas V (AV-080) OFT Launch Vehicle**

- Booster, Centaur and Launch Vehicle Adapter (LVA) production complete
 - Centaur: Arrived at CCAFS on 10/18/18
 - LVA: Arrived at CCAFS on 11/12/18
 - Booster: Arrived at CCAFS on 12/6/18
- AV-080 Booster horizontal processing complete – Ready to stack
- AV-080 Centaur stacked and mated to LVA and ISA – Ready to mate to Booster

- **System Level-Subsystem Level Testing**

- Structural Test Article (STA) testing completed
- Environmental Qualification Testing (EQT) completed
- Parachute System Qualification Testing (PSQT) 5/5 completed
- Service Module Hotfire 2.0 Testing completed
 - Low Altitude Abort and Nominal Mission sequences
- Parachute Compartment Reliability Testing underway (3/6 completed)
 - Remaining 3 tests planned throughout the fall

- **OFT Joint Tests and Analysis with ISS Remaining**

- JA 9 Clearance During Docking/Mated Ops (SC# 3) Final As-Built compare NET 10/28/19
- JT 10 Crew Equipment Interface Test (CEIT) (SC #3)
- JT 11 Microbial and Fungal Sampling (SC #3)
- JT 12 Closed Hatch Off Gassing (SC #3)

Spacecraft #3 in final prep



Atlas V Booster AV-080



Boeing Crew Flight Test Status



Crew Flight Test (CFT) Trending to Early 2020 Launch Readiness

• Spacecraft #2 - CM/SM Basic Build In-work Completed

- Upper dome/lower dome mated 10/22/2019
- Docking System Latch Actuator Installation
- Atmosphere Revitalization System (ARS) component assembly build-up
- NAFION assembly and installation
- Removal of Orbital Maneuvering And Control (OMAC) Isolation Valves
- Active Thermal Control System (ATCS) Check valve test
- Flexhose precision cleaning
- Crew suited training activities ongoing

Remaining

- Harness High Potential and Continuity Tests
- LRS Panel buildup
- PCS Panel buildup
- Command Valve Panel rework
- ATCS assembly/bellows rework
- Doghouse reaction control system isolation valve inspection
- Three way valve installation
- OMAC bracket modification

• Atlas V (AV-082) Launch Vehicle

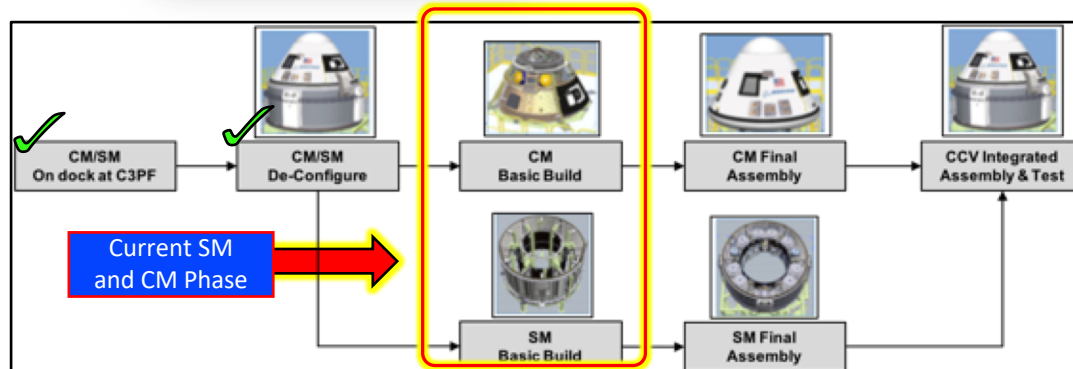
- Booster
 - Production complete
 - Arrived CCAFS on 6/1/19
- Centaur
 - Production complete
 - Arrived CCAFS on 6/1/19
- Launch Vehicle Adapter
 - In work on remaining Aeroskirt/Truss manufacturing and assembly activities
 - Prep for shipment to CCAFS fall/winter 2019



Spacecraft #2



CFT suited crew training





Boeing Operations Status



Simulations, Exercises and Training

– DoD Human Spaceflight Support Office Joint Tactical Exercise

- Water Rescue Training USAF Det 3 and 920th Rescue Wing, CCP, FOD

– Joint Ascent Simulations with ULA and NASA

- OFT Integrated Crew Exercise (ICE) #1
- On-Pad Crew Emergency Egress testing
- OFT ICE #2
- OFT Final Mission Dress Rehearsal (MDR) planned just prior to launch
- OFT Wet Dress Rehearsal Planned (WDR) just prior to launch

– Boeing OFT Simulations Completed

- Systems Rehearsal #1a and 1b (On-Orbit & Un-dock to Landing)
- Systems Rehearsal #2 (On-Orbit)
- Systems Rehearsal #3 (Un-dock to Landing)
- MDR Pt A (Ascent to Dock)

– Boeing and NASA ISSP Joint Simulations

- Six (6) Joint Rendezvous docking simulations with ISS
- Two (2) Undocking sims with ISS
- Three (3) Mission specific Joint Rendezvous, Docking, and Departure simulations planned prior to launch

– Boeing Landing Simulations

- Field equipment integration and training at WSMR site
- Landing Recovery Team Paper Sim #5 and 6
- Landing Systems Rehearsal #1
- OFT Landing Systems Rehearsal #2 (Early Return)
- OFT Landing Site and Systems Stand Alone Rehearsal
- OFT MDR Pt B (Undock to Landing) planned for fall/winter 2019



Water rescue contingency training



NASA/Boeing landing exercise



Boeing/David Clark spacesuit



Airstream/Boeing crew transport





SpaceX IFAT/Demo-2 Mission Status





Dragon Static Fire Anomaly Investigation



SpaceX encountered an anomaly during attempted static fire testing of the SuperDraco propulsion system on 4/20/19 resulting in the loss of the vehicle

- A formal investigation was begun, which included NASA participation
- Fault tree disposition is nearly complete
- The SpaceX static fire anomaly investigation team briefed NASA leadership on progress 8/15/19
- Anomaly associated corrective actions and design changes were identified and already being implemented by SpaceX
- Prior to the IFAT Anomaly SpaceX was already planning to make a few changes between DM-1 and DM-2
 - Design changes on the low-flow side of the propulsion system were approved on 6/20/19
 - Changes on the high-flow side of the system are finalized, with ground-testing nearly complete
 - Hardware modifications installed August/September
 - Static Fire and IFAT capsule shipped to KSC on 9/25/19
 - Static Fire Test Readiness Review conducted on 10/21/19 with a delta TRR on 10/26 to discuss prop module testing
 - Static fire test NET 11/2/19
- **NASA plans to ensure that the necessary hazards and controls resulting from all changes get incorporated into the prop system hazard reports prior to approving them for Phase III (DM-2)**
 - Team is coordinating verification evidence product impacts and constraints with the respective requirement owners



DM-1 Dragon on test-stand prior to anomaly



SpaceX In-Flight Abort Vehicle Status



In-Flight Abort Test (IFAT) Trending to Early December Launch Readiness - Targeted after CRS 19

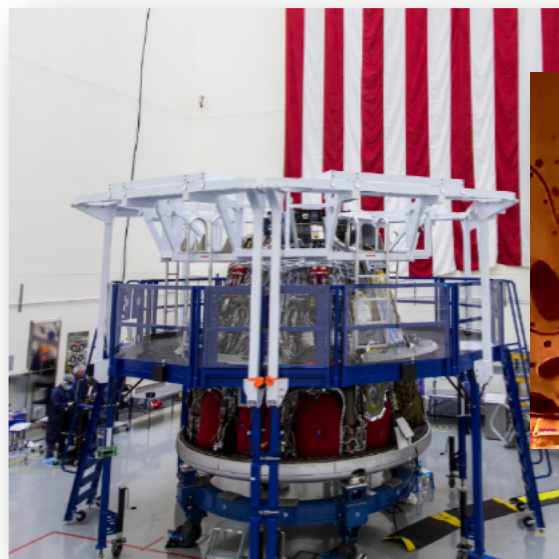
- Focus on integration of the updated propulsion system and pressure system integration

- **Test Summary**

- Launch from LC-39A at KSC
- S1B escape mode initiated at ~88s MET
- Test article consists of:
 - F9 Block 5 4th flight booster and interstage
 - F9 Block 5 2nd stage with MVacD simulator (no engine)
 - Stage extension, trunk, and Dragon Capsule 205 incorporating SuperDraco propulsion system updates since static fire anomaly
- IFAT F9 Static Fire and IFAT will be dry-runs for Demo 2+ ops support teams including exercising crew timeline

- **Status**

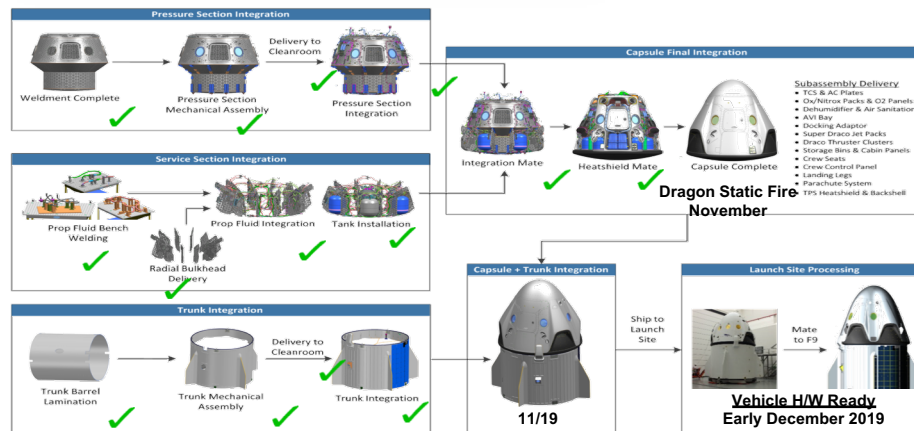
- IFAT trunk shipped to CCAFS 8/16/19
- IFAT Capsule shipped to CCAFS 9/27/19
 - Open installation work transferred to CCAFS (final harnessing, pod panels, nosecone)
- 1st stage refurbishment completed in Hawthorne shipped to CCAFS 9/22/19
- 2nd stage proof/tanking testing complete, awaiting shipment to CCAFS
- Re-baseline NASA/SpaceX IFAT TIM conducted 9/25/19



IFAT spacecraft



Testing the upgraded launch escape system





SpaceX Demo-2 Vehicle Status



Demo-2 Currently Trending to First Quarter 2020 Launch Readiness

• Dragon Spacecraft

- Docking Adapter installed
- SuperDraco ATP complete
- Trunk structure is complete
- Avionics and system checkouts in-work to test integrated systems
- Heat Shield build is complete
- Expected to ship to KSC in early December

Administrator Jim Bridenstine and Elon Musk with DM-2 spacecraft and spacesuits



• Falcon 9 Launch Vehicle

- 1st Stage shipped to McGregor and stage testing completed
- Static fire test 8/29/19
- Decision reached regarding MVacD upper stage engine configuration
 - Upper stage shipment to McGregor in October/November
 - Upper stage testing in November and ship to CCAFS in time for launch readiness review

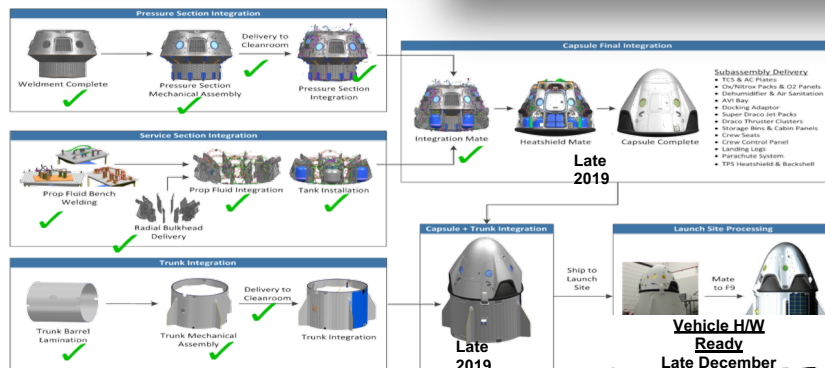


DM-2 suited crew training



• Spacesuit production of primary suits nearing completion

- Backup suit production in work





SpaceX Operations Status



Simulations, Exercises and Training

- Demo-2 Crew completed Crew Training Events
 - Integrated Cabin Review Demonstrations in the Buck (Part 1)
 - Integrated Cabin Review Demonstrations in the Buck (Part 2)
- Developed the CCP Mission Support Team Training Plan
- Conducted training for Mission Support Team via Joint Simulations and Mission Management Team Simulations
 - Part of the Mission Management Team Sims and Joint Simulations with SpaceX
 - Conducted SpX CRS-14 and SpX CRS-15 Flight Shadowing Training exercises in MCC-X, LLCC, MCC-H and Hangar AE locations
 - Completed training exercises for two F9 missions supported by LSP team at Hangar AE
- **Joint SpaceX and NASA demonstrations on Go Searcher**
 - Starting condition: Capsule on the recovery boat and ready for crew egress
 - Nominal Runs: Practiced crew egress, medical evaluation and crew transportation to the handover airport (Skid Strip CCAFS)
 - Contingency Runs: Practiced declaring a medical emergency, executed crew egress, contingency medical care, Helo landing, Helo loading, Helo takeoff and transfer at Dedicated Medical Care Facility
- **Crew Operations and LC39A**
 - Successful dry-run of Day of Launch Closeout Crew Procedures with representative crew members, space suits and transportation vehicles
 - GO Searcher spacecraft recovery vessel sea trials for Demo-1
- **Day of Launch Crew Ops Dry-Run**
 - Completed a high-fidelity demonstration of select pre-launch activities
 - Large scale coordination of Transport, Security and Safety assets
 - Exercise communication infrastructure
 - Introduce full Closeout Team to Ops
- **Full-scale Medical Triage Exercise**
 - NASA medical, Decon team, DoD DET-3, NASA helo, SpaceX closeout team participation



Nominal and contingency crew training exercises



Joint NASA, SpaceX, DoD shipboard exercises





Enabling Commercial Spaceflight



Executing Mission Requirements Through Inter-Agency Agreements and Collaboration

- **Federal Aviation Administration (FAA) and Department of Commerce (DOC)**
 - Mission licensing: launch, re-entry, launch site and operator
 - Air Traffic Management - public health and safety
 - Jurisdiction and authority during different phases of flight
 - Third-party indemnification
 - Cross waivers for government payloads/property
- **Department of Defense (DoD)**
 - U.S. Air Force Detachment 3 Partnership
 - U.S. Air Force Eastern Range
 - Launch and Entry Steering Group
- **National Oceanic and Atmospheric Administration (NOAA)**
 - SARSAT - Search and Rescue Satellite Aided Tracking
- **Federal Communications Commission (FCC) and National Telecommunications and Information Administration (NTIA)**
 - Spectrum usage and authorization
 - Ensuring secure communication pathway availability
- **National Transportation and Safety Board (NTSB)**
 - Independent investigation authority





Space Act Agreements





Blue Origin Status



Commercial Space Capabilities Collaboration (CSCC) Space Act Agreement (SAA)

- **Recent Progress**
 - Parachute, structures, and mission operations TIMs
- **Latest Technical Exchanges**
 - Launch vehicle technical TIMs, documentation requests
 - Space Shuttle historical technical reports
- **Look Ahead**
 - KSC structures technical interaction
 - SAA Milestone 8 Review



New Glenn



New Shepard



New Shepard NS-10



Sierra Nevada Corporation Status



Commercial Crew Integrated Capabilities (CCiCap) Space Act Agreement (SAA)

Recent Progress

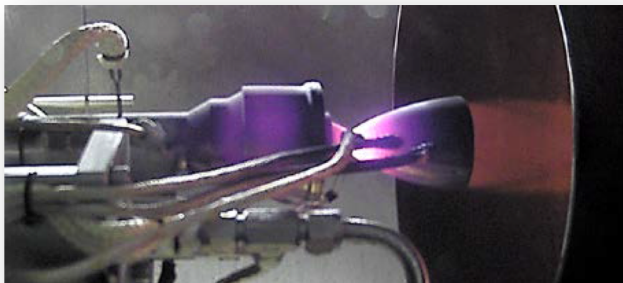
- Milestones 42 and 43 Review Complete 6/19
 - Dream Chaser RCS development testing and aerodynamic database review
- RCS thruster testing ongoing thru fall 2019
- Ames TPS Arc-Jet testing and aero wind tunnel testing continue into 2020
- SNC commits to Tail #2 (2nd vehicle), ready for services early 2023

Look Ahead

- Delivery of Dream Chaser Tail #1 Body Assembly to SNC from Lockheed Martin late Sep 2019
- Assembly Integration and Test beginning mid-Oct 2019 at Louisville facility
- Milestone 44: Lessons Learned for Crew Transportation TIM Feb 2020
- Uncrewed Dream Chaser and Cargo Module ship to Plumbrook Q2 2021
- 1st uncrewed Launch Q4 2021 aboard ULA Vulcan



*Dream Chaser Cargo
Module fabrication*



RCS Thruster testing



Wind tunnel testing



Dream Chaser body assembly

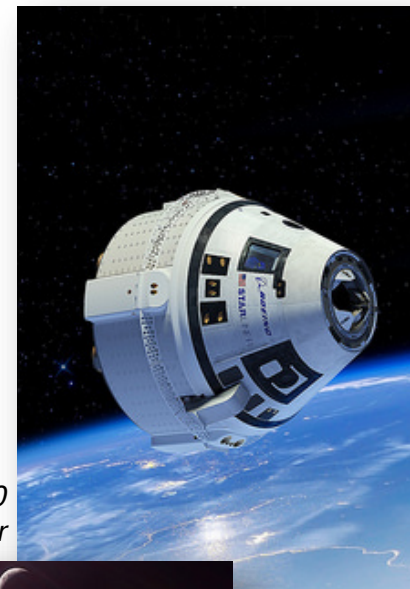


Summary



CCP continues to facilitate the development and certification of U.S. industry-based Crew Transportation Systems

- **Boeing and SpaceX are meeting contractual milestones and maturing their spaceflight systems**
 - Risks are being identified and important design challenges are being addressed
 - A substantial amount of hardware is in development, test and qualification by both providers
 - NASA is engaged in meaningful insight
- **Both providers are making tangible progress toward test flights and post certification missions to the International Space Station**
- **CCP has a robust and efficient processes for certification, including addressing waivers and deviations**
 - There is progress in burn-down of key certification products
- **Crew members are training for specific missions**
- **Inter-agency collaboration continues to help enable the success of the commercial spaceflight industry**
- **There is significant work ahead for crewed flight**



*Boeing CST-100
Starliner*



*SpaceX Crew
Dragon*

